

A PIN diode controlled dual-tuned MRI RF coil and phased array for multi nuclear imaging.

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Public Summary:

MR imaging of nuclei other than hydrogen has been used to investigate metabolism in humans and animals. However, MRI observable nuclei other than hydrogen are not as abundant and as a result the image SNR is lower. Dual-tuned radio frequency (RF) coils are developed for these studies in which high-resolution structural images are acquired using hydrogen and metabolic information is acquired by exciting the other nucleus. Using a dual-tuned coil, the experimenter avoids the inconvenience of moving the patient out and replacing the RF coil for imaging different nuclei. This also eliminates image registration problems. However, the common scheme of using trap circuits for dual-tuned operation results in increased coil losses as well as problems in obtaining optimal tuning and matching at both frequencies. Here, a new approach is presented using PIN diodes to switch the coil between two resonance frequencies. This design eliminates the need for the trap circuit and associated losses from the self-resistance of the trap circuit inductors. At the operating frequencies we used, the equivalent series resistance of an inductor is higher than that of the PIN diodes. In order to test the efficacy of this new approach, we first built two surface coils of identical geometry, one with the conventional trap circuits and one with the PIN diode switches. We also studied the performances of both coils when the coils are divided into shorter conductor segments by adding more tuning elements. It is known that dividing the coil into shorter conductor segments helps reduce radiation and electric field losses. We explored this effect for both coils at both operating frequencies. Finally, a dual-tuned receive-only phased array was designed and built with the PIN diode circuit to switch between two resonance frequencies. A conventional dual-tuned birdcage coil was designed and built to transmit RF power. A unique feature of this coil is that the RF power is fed through two separate sets of four ports for more uniform ^1H and ^{23}Na excitation. We demonstrated that the performance is significantly improved at both frequencies with the PIN diode switched dual-frequency operation compared to an identical coil with a trap circuit.

Scientific Abstract:

MR imaging of nuclei other than hydrogen has been used to investigate metabolism in humans and animals. However, MRI observable nuclei other than hydrogen are not as abundant and as a result the image SNR is lower. Dual-tuned radio frequency (RF) coils are developed for these studies in which high-resolution structural images are acquired using hydrogen and metabolic information is acquired by exciting the other nucleus. Using a dual-tuned coil, the experimenter avoids the inconvenience of moving the patient out and replacing the RF coil for imaging different nuclei. This also eliminates image registration problems. However, the common scheme of using trap circuits for dual-tuned operation results in increased coil losses as well as problems in obtaining optimal tuning and matching at both frequencies. Here, a new approach is presented using PIN diodes to switch the coil between two resonance frequencies. This design eliminates the need for the trap circuit and associated losses from the self-resistance of the trap circuit inductors. At the operating frequencies we used, the equivalent series resistance of an inductor is higher than that of the PIN diodes. In order to test the efficacy of this new approach, we first built two surface coils of identical geometry, one with the conventional trap circuits and one with the PIN diode switches. We also studied the performances of both coils when the coils are divided into shorter conductor segments by adding more tuning elements. It is known that dividing the coil into shorter conductor segments helps reduce radiation and electric field losses. We explored this effect for both coils at both operating frequencies. Finally, a dual-tuned receive-only phased array was designed and built with the PIN diode circuit to switch between two resonance frequencies. A conventional dual-tuned birdcage coil was designed and built to transmit RF power. A unique feature of this coil is that the RF power is fed through two separate sets of four ports for more uniform ^1H and ^{23}Na excitation. We demonstrated that the performance is significantly improved at both frequencies with the PIN diode switched dual-frequency operation compared to an identical coil with a trap circuit.